WHITE PAPER NO. 9 – REMEDIAL DECISION-MAKING FOR THE LOWER FOX RIVER/GREEN BAY REMEDIAL INVESTIGATION, FEASIBILITY STUDY, PROPOSED REMEDIAL ACTION PLAN, AND RECORD OF DECISION

Response to a Comments on the

REMEDIAL INVESTIGATION FOR THE LOWER FOX RIVER AND GREEN BAY, WISCONSIN, FEASIBILITY STUDY FOR THE LOWER FOX RIVER AND GREEN BAY, WISCONSIN, PROPOSED REMEDIAL ACTION PLAN FOR THE LOWER FOX RIVER AND GREEN BAY, AND RECORD OF DECISION FOR THE LOWER FOX RIVER AND GREEN BAY

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ABSTRACT

This White Paper was prepared to document the remedial decision-making process for the Lower Fox River/Green Bay remedy selection. Development of the remedy selection was consistent with the evaluation process under United States Environmental Protection Agency (EPA) guidelines for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), National Research Council (NRC) guidance and EPA guidance for the management of polychlorinated biphenyl (PCB)-contaminated sites. This White Paper provides an overview of the supporting studies and tools used, the remedy evaluation process is described and discussed, and the remedy itself is briefly summarized. As shown in this White Paper, these tools together with the *Remedial Investigation for the Lower Fox River and Green Bay, Wisconsin* (RI) (RETEC, 2002a), *Feasibility Study for the Lower Fox River and Green Bay, Wisconsin* (FS) (RETEC, 2002b), and *Proposed Remedial Action Plan, Lower Fox River and Green Bay* (Proposed Plan) (WDNR and EPA, 2001) demonstrate the necessity to remediate, the availability of the remedial technology, and what may be reasonably expected from the remediation.

1 INTRODUCTION

In October 2001, the EPA and the Wisconsin Department of Natural Resources (WDNR) issued a Proposed Plan for addressing PCB contamination of the Lower Fox River and Green Bay. Development of the Proposed Plan and the selection of a remedy were the end result of an extensive evaluation process consistent with EPA guidelines for CERCLA projects in accordance with the federal National Contingency Plan (NCP). The remedy selection process was also consistent with NRC recommendations and other EPA guidance regarding the management of PCB-contaminated sediment sites. In addition to a site-specific RI/FS, selection of the proposed remedy was based on consideration of information provided by numerous supporting studies, tools, and public comments. Each of these supporting efforts contributed to the remedy evaluation process by providing a wide spectrum of analyses that consider the full range of possible outcomes for each remediation alternative. When collectively considered with the RI/FS, these tools:

1. Clearly demonstrate the need to remediate Lower Fox River contaminated sediments;

2. Show that technology exists to implement the selected remedy; and

3. Provide an understanding of what may be reasonably expected after the remedy is implemented.

An overview of the supporting studies contributing to the remedy evaluation process follows. After this overview, the remedy selection process is described and discussed. This White Paper then concludes with a brief summary of the selected remedy to restore the environmental quality of the Lower Fox River and Green Bay. The selected remedy is further described in the ROD for the Site.

2 OVERVIEW OF SUPPORTING STUDIES AND TOOLS

The types of supporting studies contributing to the development of the Proposed Plan for the Lower Fox River and Green Bay include:

1. Field studies delineating the extent and distribution of PCB in water, sediment, and fish;
2. Human health and ecological risk assessments;
3. Analyses of the spatial and temporal PCB concentration trends in sediment and fish;
4. Contaminated sediment depth and sediment bed stability;
5. Site-specific chemical transport and biota modeling;
6. Sediment remediation evaluation and demonstration projects; and
7. Public input into the remedy selection process.

TABLE 1 LOWER FOX RIVER AND GREEN BAY REACH, ZONE AND OPERABLE UNIT DESCRIPTIONS

Location	Description	Reach or Zone	Operable Unit
Lower Fox River	Little Lake Butte des Morts	Reach 1	1
	Appleton to Little Rapids	Reach 2	2
	Little Rapids to De Pere	Reach 3	3
	De Pere to Green Bay	Reach 4/Zone 1	4
Green Bay	Lower Fox River mouth to Little Tail Point	Zone 2	5
	Little Tail Point to Chambers Island (West)	Zone 3a	
	Little Tail Point to Chambers Island (East)	Zone 3b	
	Chambers Island to Lake Michigan interface	Zone 4	

An overview of each of these items and the lessons learned from them are discussed below. In the RI/FS, the River and Bay were described in terms of reaches, zones, and Operable Units (OUs) as summarized in Table 1. The same terminology is also used in this White Paper.

2.1 FIELD STUDIES TO DELINEATE THE EXTENT AND DISTRIBUTION OF PCBS

PCB contamination of the Lower Fox River and Green Bay has been routinely monitored since the 1970s. Over the past 30 years, numerous field studies have been conducted to determine the extent and distribution of PCB contamination in the water, sediment, and fish of the Lower Fox River and Green Bay. In recent years, EPA, WDNR, the United States Geological Survey (USGS) and other groups have completed many field studies.

A summary of these studies is presented in Table 2. Since the release of the RI/FS and supporting documents, additional field sampling efforts have been completed.

The Fox River Database (FRDB), a site-specific data management system, was developed to compile all field data for the Lower Fox River/Green Bay project area. As part of database development, efforts were also undertaken to review data quality of all data was compiled into the database. More than 500,000 individual data records from over 35 different field studies are compiled into the FRDB. These data provide critical, site-specific information that was used to construct the RI, FS, risk assessments, and other supporting studies. Further information regarding FRDB development is presented in the *Data Management Summary Report* found in Appendix A of the RI (RETEC, 2002a).

Beyond the data in the FRDB, the overall project database includes contaminant release data for each major industrial and municipal wastewater facility that discharges to the Lower Fox River. The contaminant release records were further augmented by discharge information each facility submitted to the U.S. Department of Justice as part of Natural Resource Damage Assessment (NRDA) efforts. These records provide discharge information for the entire period of PCB use and occurrence in the Lower Fox River (1954–present). Further information regarding the releases of solids and PCBs is presented in Technical Memorandum 2d (WDNR, 1999a).

The sufficiency of the project database was examined by an EPA-sponsored review panel prior to the first release of the draft RI/FS in February 1999. This peer review found that the underlying database for the RI/FS and supporting projects was sufficient to determine the distribution of contaminants, support identification, and selection of a remedy using technologies employed at other large-scale sites, and select a remedy.

TABLE 2 RECENT FIELD DATA COLLECTION EFFORTS FOR THE LOWER FOX RIVER AND GREEN BAY

Year	Study	Media Sampled		
		Water	Sediment	Fish
1989–1990	EPA Green Bay Mass Balance Study (GBMBS)	✓	✓	✓
1991–1994	Deposit A RI/FS (WDNR)	✓	✓	
	USGS Follow-up to GBMBS	✓		
	WDNR fish sampling			✓
1994–1996	RI/FS for select deposits (WDNR/GAS)		✓	
	WDNR detailed sediment characterizations		✓	
	WDNR fish sampling			✓
	EPA Lake Michigan Mass Balance Study (LMMBS)	✓		
1998–1999	Deposit N Demonstration Project (WDNR)	✓ [1]	✓ [2]	
1998	RI/FS Supplemental Sampling (WDNR/RETEC)	✓	✓	✓
1998–2001	FRG:[3] selected portions of River and Bay	✓	✓	✓
	SMU 56/57 Demonstration Project	✓ [1]	✓ [2]	

[1] Water samples also include contaminant analyses for wastewater effluent.
[2] Sediment samples also include contaminant analyses for dewatered sediments.

2.2 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

Human health and ecological risk assessments specific to the Lower Fox River and Green Bay were completed as part of RI/FS development. These studies examine the risks posed by exposure to PCBs and other chemicals of concern (COC). These studies consider the most significant means by which chemical exposures and risks occur. For PCBs in the Lower Fox River and Green Bay, the most significant risks to human health and wildlife occur though the consumption of contaminated fish. Human cancer risks were found to be 1,000 times greater than the 10^{-6} (one in one million) cancer risk management level and noncancer hazards were found to be 20 times greater than background risks. In addition to human health risk, ecological receptors such as fish-eating birds and mammals were also found to be at risk. The conclusion of these studies is that PCBs in the Lower Fox River and Green Bay present an unacceptable level of risk to human health and the ecosystem. The conclusion that PCBs are unacceptably high is also confirmed by the fact that fish consumption advisories have been in place for this region continuously since the risks were first evaluated in 1976. Further information regarding the risk assessments of PCBs is presented in the *Baseline Human Health and Ecological Risk Assessment for the Lower Fox River and Green Bay, Wisconsin, Remedial Investigation and Feasibility Study* (BLRA) (RETEC, 2002c).

The risk assessment studies were examined by an FRG-sponsored peer review panel following the February 1999 release of the draft RI/FS. The peer review was conducted at the direction of the Association for the Environmental Health of Soils (AEHS). One significant peer review panel recommendation was the need to conduct a probabilistic risk assessment. In response to peer review panel recommendations, WDNR conducted a probabilistic risk assessment for human heath issues for the October 2001 release of the final RI/FS (see Appendix B of the BLRA entitled “Additional Evaluation of Exposure to PCBs in Fish from the Lower Fox River and Green Bay”). This assessment addresses concerns related to prenatal and developmental effects and more clearly states the basis for risk assumptions.

2.3 ANALYSES OF SPATIAL AND TEMPORAL PCB CONCENTRATION TRENDS IN SEDIMENT AND FISH

Analyses of spatial and temporal PCB concentration trends in sediment and fish were completed as part of RI/FS development. Identification of spatial and temporal trends in sediments is inherently difficult because field observations were collected at different horizontal locations, at different vertical locations relative to a fixed datum, and at different times. Clear identification of fish tissue PCB concentration trends is also difficult because fish are mobile and the predominant source of contaminants have shifted from wastewater discharges to sediments over time.

Due to the factors that complicate identification of trends, two studies employing different assumptions were conducted to examine sediment PCB trends. The first study (TMWL, 2002) assumes that, in the absence of a reference elevation datum, changes in

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[3] The FRG is a group of paper companies considered to be the potentially responsible parties (PRPs) for cleanup actions at this Site.

sediment bed elevation were negligible in order to estimate trends with depth in the sediment column. This study also assumed that none of the differences in observed PCB concentrations over time could be attributed to differences in laboratory procedures. The second study (see Appendix B of WDNR, 2001a) assumes that bed elevation changes are significant based on the results presented in Technical Memorandum 2g (WDNR, 1999b) and some of the differences in observed PCB concentrations over time are attributed to differences in laboratory procedures based on the results of independent inter-lab comparisons. Despite the wide differences in assumptions, these two studies both conclude that sediment PCB trends are highly variable (some decreasing, some constant, some increasing) and that trends cannot be assumed to be uniformly decreasing in future years.

To examine fish tissue PCB concentration trends, a study was conducted by TMWL (2002). This study assumes that fish experience PCB exposures in the area proximate to their collection location and that none of the differences in observed PCB concentrations over time could be attributed to differences in laboratory procedures. To account for differences in exposure regimes over time, contemporary fish tissue PCB concentration trends were segregated from historical trends by a "breakpoint." The years used as breakpoints range between the year when the last wastewater discharger to the River installed improved treatment facilities (P.H. Glatfelter Company in August 1979) to a year when residual PCB discharges were reduced to very small levels (the mid- to late 1980s). Years before the breakpoint represent a period when both point source discharges and sediments may have affected fish tissue PCB concentrations. Years after the breakpoint represent a period when only sediments are believed to have affected fish PCB burdens. This study concludes that in recent years, the rates at which fish tissue PCB levels have declined is significantly less than the historical period where ongoing PCB discharges occurred.

2.4 CONTAMINATED SEDIMENT DEPTH AND SEDIMENT BED STABILITY

Analyses of contaminated sediment depth and sediment bed stability were completed as part of RI/FS development. These studies examine the depths to which contaminants occur in the sediment column of the River and the stability of the sediment bed. These studies provide information needed to evaluate whether sediments contaminated with PCBs may be diluted by natural burial or contribute to risks in-place (by mixing) or elsewhere (by transport). Additional studies were also completed by EPA (*White Paper No. 3 – Fox River Bathymetric Survey Analysis*, 2002) and for the FRG (LTI, 2002) as part of independent efforts.

In the Lower Fox River, PCBs have been observed more than 5 meters (16 feet) below the sediment-water interface at some locations.[4] Based on the observations compiled in the FRDB and additional information regarding the thickness of Lower Fox River sediments, the volumetric extent and distribution of PCBs in the sediment column of the river was estimated in Technical Memorandum 2e and follow-up efforts (WDNR, 1999c, 2000a). As described in the RI (RETEC, 2002a), in the River reaches between Lake

[4] This condition was observed in the area around SMU 56/57 prior to the start of the pilot project for that site.

Winnebago and De Pere (OUs 1–3), more than 97 percent of the PCB mass is located within the upper 100 cm (3.3 feet) of sediment; and for the River reach between De Pere and Green Bay (OU 4), more than 90 percent of the PCB mass is within the upper 200 cm (6.6 feet) of sediment. A similar study was also completed for Green Bay (WDNR, 2001b).

The elevations of the sediment bed within the bounds of the River navigation channel between the De Pere dam and Green Bay are routinely monitored by the United States Army Corps of Engineers (USACE). Additional surveys have been completed by EPA and the USGS. Based on these data sources, three separate studies examining sediment bed elevations changes in sections of the River that have not been dredged in more than 30 years have been completed. As summarized in Technical Memorandum 2g (WDNR, 1999b) and follow-up efforts (see Section 4.2.2.1 of WDNR, 2001a), these surveys demonstrate that the sediment bed of the Lower Fox River is a very dynamic environment and that bed elevations can increase or decrease by more than 200 cm (6.6 feet) even during periods when there are very small net increases in bed elevation. These studies also concluded that the net rate of sediment accumulation can be very small compared to gross changes in bed elevation. A study completed by the EPA FIELDS Group (2002) reaches similar conclusions for undredged portions of the river channel. A third study completed for the FRG (LTI, 2002) that considered radioisotope patterns in sediment also concluded that sediment bed elevations between the De Pere dam and the River mouth may be decreasing in response to declining water levels in the Bay. These changes in sediment bed elevations are believed to result in episodic sediment mixing and downstream transport.

As described by WDNR (1999b, 2001a), it should be noted that the majority of the bed elevation data used for these studies was collected by the USACE as part of Class I surveys. The accuracy of these surveys was confirmed by field tests of the actual combined errors (equipment and procedural) of measurements. Data collected at the Sediment Management Unit (SMU) 56/57 demonstration site in August 1999 indicates that the combined vertical accuracy achieved by the USACE Kewaunee Office was approximately ±4 cm (WDNR, 1999d).

Several specific conclusions can be drawn from these studies. First, PCB contamination of Lower Fox River sediments is extensive. However, more than 97 percent of the PCB mass of OUs 1 through 3 resides in the upper 100 cm of the sediment column and more than 90 percent of the PCB mass in OU 4 resides in the upper 200 cm of sediment. Second, the sediment bed of the River can be a very dynamic environment. Large increases and decreases in sediment bed elevations were observed even for periods when there were very small net increases in bed elevation. Because natural rates of net sediment accumulation (burial) can be small, the potential to restore the River by natural burial (a passive PCB-contaminated sediment approach) may be limited. Third, the portions of the sediment column where most of the PCB mass in the sediment resides can be subject to episodic mixing and transport. Further, episodic mixing and transport of sediments between the De Pere dam and the River mouth (OU 4) may occur now and in the future in response to cyclical changes in water levels in Green Bay/Lake Michigan. When considered together, these studies indicate that the sediment bed of the Lower Fox

River is not necessarily a stable environmental for *in-situ* management of PCB-contaminated sediments and that the stability of the sediment bed can change over time in response to changes in conditions such as declining water levels.

Finally, it is worth noting that in terms of the dynamics of sediment bed elevation changes, the Lower Fox River is not unique. Similar ranges of bed elevation changes have been observed in the Sheboygan River (Wisconsin) (WDNR, 2000c). A recent study of bed mobility in the Sacramento River (California) also demonstrates that the bed of a river can be a very dynamic environment (Dinehart, 2002). In that study, the upper 30 cm of the sediment bed was typically found to be mobile (bedform transport) and moved downstream at rates that ranged from 0.43 to 2.01 meters per day (Dinehart, 2002).

2.5 SITE-SPECIFIC CHEMICAL TRANSPORT AND BIOTA MODELING

Site-specific PCB transport and food web bioaccumulation models were developed as part of the RI/FS. These models use mass balance and bioenergetics concepts to estimate the rates at which chemical concentrations in water, sediment, and biota (plankton, fish, etc.) change. For the RI/FS, four models were developed. A summary of these models is presented in Table 3. Brief descriptions of the models are presented in the sections that follow. Full descriptions of the models and all associated supporting studies are presented in the *Model Documentation Report for the Lower Fox River and Green Bay, Wisconsin* (MDR) (WDNR and RETEC, 2002) that accompanies the RI/FS.

These models have been calibrated to conditions in the Lower Fox River and Green Bay. The primary use of the calibrated suite of models was to help estimate, in a comparative sense, what timeframe might be required to achieve acceptable fish tissue PCB concentrations for a series of different sediment action levels. Collectively, these modeling studies suggest: (1) that at present rates of change (the no action alternative) it may take many decades before PCB exposures and fish tissue PCB concentrations meet acceptable risk levels; (2) rates of PCB change (decline) may be improved by managing PCB levels in sediments; and (3) the degree to which rates of PCB decline may be improved is directly related to the extent of sediment PCB management efforts (more extensive management yields more rapid declines).

TABLE 3 SITE-SPECIFIC CHEMICAL TRANSPORT AND BIOTA MODELS DEVELOPED FOR THE RI/FS

Model	Sites	Use	MDR Location
wLFRM	Lower Fox River (OUs 1–4)	Water and Sediment Quality	Appendix B
GBTOXe	Green Bay (OU 5)	Water and Sediment Quality	Appendix C
FRFood	Lower Fox River (OUs 1–4)	Biota	Appendix D
GBFood	Lower Fox River (OU 4) Green Bay (OU 5)	Biota	Appendix E

The development history of these models and modeling approaches is well documented. Several generations of model development for the Lower Fox River and Green Bay system have been completed. The present generation of model applications presented in the MDR was based on information developed in conjunction with the FRG companies by a model evaluation workgroup (MEW) under the terms of a January 1997 agreement. A series of Technical Memoranda (TM) was prepared by the MEW. Each TM provides detailed analyses of a key aspect of model development such as solids and PCB loads, sediment transport dynamics, and initial conditions. A more complete description of each TM is presented in the MDR (WDNR and RETEC, 2002). In addition to the TM, numerous publications, technical reports, and peer review documents describing aspects of the Whole Lower Fox River Model (wLFRM), Enhanced Green Bay Toxics Model (GBTOXe), Fox River Food Web Model (FRFood), and Green Bay Food Web Model (GBFood) development and performance are available. These include other documents: AGI (2000), Bierman et al. (1992), Connolly and Thomann (1992), Connolly et al. (1992), DePinto et al. (1993), Gobas (1993), Gobas et al. (1995), HydroQual (1995), HydroQual (1996), Steuer et al. (1995), Velleux and Endicott (1994), Tetra Tech, Inc. (2000), Velleux et al. (1995), Velleux et al. (1996), Velleux et al. (2001), and WDNR (1997).

2.5.1 Whole Lower Fox River Model (wLFRM)

The wLFRM was developed to examine the transport and fate of PCBs in the Lower Fox River (WDNR, 2001). The wLFRM is the result of numerous assessments of Lower Fox River water quality model performance and represents the fourth generation of model development. The wLFRM was designed to estimate PCB concentrations in the water column and sediment of the Lower Fox River. PCBs and three types of solids in the water column and sediments were simulated. The model spatial domain is the entirety of the Lower Fox River from Lake Winnebago to the River mouth at Green Bay. This region was represented as 40 water column and 165 sediment stacks. Each sediment stack has up to 10 vertical layers depending on the thickness of sediments at a given location. The sediment layers represent biologically active sediments and deeper biologically inactive sediments. Mechanisms affecting PCB transport include: advection, dispersion, volatilization, erosion and deposition of particulate phases, porewater exchange of dissolved phases, and sediment bed armoring.

The wLFRM was calibrated using data collected as part of the EPA 1989–1990 GBMBS, the 1994–1995 LMMBS, and other field studies over the period 1989–1995. Once calibrated, the primary use of the wLFRM in the RI/FS was to conduct long-term (100-year) simulations of PCB transport and fate in the Lower Fox River for conditions ranging from no action to a series of sediment management action levels. Further information regarding the wLFRM is presented in the MDR (WDNR and RETEC, 2002).

It should be noted that development of the wLFRM for the RI/FS was based on information developed in conjunction with the FRG companies by the MEW and a peer review of model performance. The MEW prepared a series of TMs. Each TM provides detailed analyses of a key aspect of model development such as solids and PCB loads, sediment transport dynamics, and initial conditions. A more complete description of each TM is presented in the MDR (WDNR and RETEC, 2002). In addition to MEW efforts, an FRG-sponsored peer review panel presented additional assessments of model performance (AGI, 2000). To the greatest extent practical, peer review panel recommendations were integrated into wLFRM development efforts.

2.5.2 Enhanced Green Bay Toxics Model (GBTOXe)

The GBTOXe was developed to examine the transport and fate of PCBs in Green Bay (HydroQual, 2001). GBTOXe is an enhanced version of the GBTOX model originally developed as part of the EPA GBMBS (Bierman et al., 1992; DePinto et al., 1993). Enhancements include finer spatial resolution and linkages to a hydrodynamics model (GBHYDRO) and a sediment transport model (GBSED) for Green Bay. GBTOXe was designed to estimate PCB concentrations in the water column and sediment of Green Bay. PCBs and three types of carbon in the water column and sediments were simulated. The carbon types considered are dissolved, biotic, and particulate detritus. The biotic and particulate detritus carbon types represent the portion of the suspended solids in the Bay with which PCBs may associate. The model spatial domain is the entirety of Green Bay from the Lower Fox River mouth to the Lake Michigan interface. This region was represented as 1,490 water column and 596 sediment segments. The water column has 10 vertical layers, each with 149 horizontal segments. The sediment layers represent biologically active sediments and deeper biologically inactive sediments. Mechanisms affecting PCB transport include: advection, dispersion, volatilization, erosion and deposition of particulate phases, porewater exchange of dissolved phases, and sediment bed armoring.

GBTOXe was calibrated using data collected as part of the 1989–1990 EPA GBMBS. The GBMBS provides the only comprehensive data for Green Bay water and sediment sufficient for model development. Once calibrated, the primary use of GBTOXe in the RI/FS was to conduct long-term (100-year) simulations of PCB transport and fate in Green Bay for conditions ranging from no action to a series of sediment management action levels. Further information regarding GBTOXe is presented in the MDR (WDNR and RETEC, 2002).

2.5.3 Fox River Food Web Model (FRFood)

The FRFood bioaccumulation model provides a mathematical description of PCB transfer within the food web of all four reaches of the Lower Fox River (OUs 1–4) and inner Green Bay (Zone 2). This model was designed to estimate PCB concentrations in the aquatic food web of the Lower Fox River (i.e., benthic organisms, phytoplankton, zooplankton, and fish) based on PCB concentrations in water and sediment. In addition to the River, FRFood also includes a portion of the Bay food web. This overlap is necessary because fish can freely move between the last reach of the River (De Pere to Green Bay) and the Bay. FRFood is functionally similar to the food web model for Green Bay (GBFood) described in Section 2.5.4. FRFood was also designed to estimate the average sediment PCB concentration needed to meet a specified target fish tissue PCB level. Each reach has a specified food web. The food web is represented as the primary energy and chemical transfer pathways from exposure sources (sediment and water) to fish species of interest. These pathways include: chemical uptake across the gill surface, chemical uptake from food by species-specific and age class-specific predator-prey relationships, chemical loss by excretion, and dilution by growth.

FRFood was calibrated using exposure concentrations defined by field data collected as part of the 1989–1990 EPA GBMBS and subsequent sampling efforts over the period

1989–1995 (RETEC, 2002c). Once calibrated, the primary uses of FRFood in the RI/FS were to: (1) estimate potential risk-based remedial cleanup levels, called sediment quality thresholds (SQTs); and (2) conduct long-term (100-year) simulations to estimate fish tissue concentrations for conditions ranging from no action to a series of sediment management action levels. For FRFood long-term simulations, exposure conditions were defined by wLFRM long-term simulation results. Further information regarding FRFood is presented in the MDR (WDNR and RETEC, 2002).

2.5.4 Green Bay Food Web Model (GBFood)

The GBFood bioaccumulation model provides a mathematical description of PCB transfer within the food web of last reach of the Lower Fox River (De Pere to Green Bay) (OU 4) (Zone 1) and all of Green Bay (OU 5) (Zones 2–4). This model was designed to estimate PCB concentrations in the aquatic food web of Green Bay (i.e., benthic organisms, phytoplankton, zooplankton, and fish) based on PCB concentrations in water and sediment. In addition to the Bay, GBFood also includes a portion of the River food web. This overlap is necessary because fish can freely move between the last reach of the River (De Pere to Green Bay) and the Bay. Each zone has a specified food web. The food web is represented as the primary energy and chemical transfer pathways from the exposure sources (sediment and water) to the fish species of interest. These pathways include: chemical uptake across the gill surface, chemical uptake from food by species-specific and age class-specific predator-prey relationships, chemical loss by excretion, and dilution by growth.

GBFood was calibrated to conditions defined by field data collected as part of the 1989–1990 EPA GBMBS (QEA, 2001) using exposures estimated by wLFRM and GBTOXe. Once calibrated, the primary uses of GBFood in the RI/FS were to conduct long-term (100-year) simulations to estimate fish tissue concentrations for conditions ranging from no action to a series of sediment management action levels. For GBFood long-term simulations, exposure conditions were defined by wLFRM and GBTOXe long-term simulation results. Further information regarding GBFood is presented in the MDR (WDNR and RETEC, 2002).

2.6 Sediment Remediation Evaluation and Demonstration Projects

A range of different PCB-contaminated sediment remediation approaches for the Lower Fox River was examined as part of the RI/FS. Passive and active methods for managing contaminated sediments were considered. Passive processes that can affect PCB risks include burial (dilution of PCB-contaminated sediment by the buildup of an overlying layer of cleaner sediments), dispersion (dilution of PCB-contaminated sediment through movement within the water column and the gradual settlement of this contaminated sediment), and dechlorination (detoxification by the removal of chlorine atoms from PCB molecules). Burial, dispersion, and dechlorination are processes that contribute to "natural recovery." The potential for burial of PCBs was examined as part of contaminated sediment depth and sediment bed stability studies. The potential for continued dispersion remains high as long as PCBs continue to remain at the sediment surface, which results in downstream contamination and movement of PCB mass into Green Bay. The potential for PCB dechlorination was examined as part of a dechlorination study described in Section 2.6.1. Active methods to manage PCBs include capping and dredging. Capping was examined as part of the FS (RETEC, 2002b). General aspects of dredging were examined as part of sediment technologies study described in Section 2.6.2.

In addition to the dechlorination and sediment technologies supporting studies, the results of two sediment remediation demonstration projects on the Lower Fox River were also considered in the RI/FS. Sediment removal demonstration projects were completed at two sites: Deposit N and SMU 56/57. These two projects provided information regarding insight on the technical and administrative feasibility of managing remediation projects for the Lower Fox River. In addition to providing information regarding the ability to complete environmental dredging projects on the Lower Fox River, the projects also provided information regarding were to: evaluate implementation issues (access agreements, insurance, site access, contracting, permits, and liability waivers and indemnification); conduct monitoring (operational, deposit mass balance, process mass balance, river transport, and air); and provide information on remediation prior to the initiation of full-scale work.

These demonstration projects showed communities in the Fox River Valley what dredging looked like and demonstrated that: (1) there were no community disruptions, (2) PCBs can be permanently removed from river, (3) PCB-contaminated sediments can be disposed in a local landfill, and (4) there was compliance with all permits and permit requirements. In addition, at the SMU 56/57 project, additional monitoring showed there were no resuspension problems from dredging and there is no risk from air releases from dredging. These projects conclusively demonstrated that successful dredging projects can be conducted on the Lower Fox River.

2.6.1 Natural Dechlorination

A PCB dechlorination study was conducted as part of the RI/FS. Dechlorination is the only potential means by which PCB toxicity may be reduced under natural conditions (passive management). The *Review of Natural PCB Degradation Processes in Sediments* (Dechlorination Study) (see Appendix D of RETEC, 2002b) showed that dechlorination does not occur where PCB concentrations are less than 30 mg/kg. While certain locations in the River exceed this threshold, PCB concentrations at most locations are less than 30 mg/kg. As a result, the study concludes that passive management of PCBs by dechlorination is not a reliable or effective means to reduce PCB risks for Lower Fox River sediments.

2.6.2 Sediment Technologies Memorandum

To assess concerns about the short-term and long-term effectiveness of environmental dredging as a remedial alternative, WDNR commissioned an evaluation of 20 environmental dredging case studies in the a study entitled *Sediment Technologies Memorandum for the Lower Fox River and Green Bay, Wisconsin*, which can be found in Appendix B of the FS (RETEC, 2002b). The study found that dredging to achieve a specific target goal (e.g., an elevation or a concentration) can be accomplished and that dredging in soft sediments can effectively remove contamination with minimal re-suspension and downstream transport of contaminants. The study also found that environmental dredging has been effective in reducing the risk to human health in several projects. The study also identified several recommendations including the need to identify a clear target goal, having adequate site-specific knowledge, determining acceptable risks during implementation, and developing an appropriate long-term monitoring plan to verify project success.

2.6.3 Deposit N

In 1998 and 1999, WDNR and EPA sponsored a project to remove PCB-contaminated sediment from Deposit N in the Lower Fox River. The primary objective of this project was to demonstrate that dredging could be performed in an environmentally safe and cost-effective manner to manage PCB-contaminated sediments in the Lower Fox River. The Deposit N site was approximately three acres in size and contained about 11,000 cubic yards (cy) of contaminated sediment with PCB concentrations as high as 186 milligrams per kilogram (mg/kg). Sixty-five percent of the sediment volume of Deposit N was targeted for removal. Approximately 8,200 cy of sediment were removed from the site, generating 6,500 tons of dewatered sediment that contained 112 total pounds of PCBs. The total material also included approximately 1,000 cy of sediment that was removed from Deposit O, another contaminated sediment site adjacent to Deposit N.

Monitoring data from the project showed that the River was protected during the dredging and that wastewater discharged back to the River complied with all permit conditions. The project also met design specifications such as the volume of sediment removed, sediment tonnage, and allowed thickness of residual sediments. In addition to the removal of PCBs from the site, other benefits of the project included opportunities for public outreach and education on the subject of environmental dredging. In assessing project success, it should be noted that Deposit N projects goals were to test the ability of a management effort to meet design specifications that focused on PCB mass removal rather than a concentration-based cleanup. A cost analysis of this project indicated that a significant portion of the funds was expended in pioneering efforts associated with the first PCB cleanup project on the Lower Fox River and the added winter construction expenses that were incurred to meet an accelerated construction schedule. Such added costs are not typical and would not necessarily be incurred with future projects.

2.6.4 SMU 56/57

One of the projects conducted under the January 1997 agreement with the FRG companies was a sediment remediation project. The objective of this effort was to design, implement, and monitor a project in the Lower Fox River downstream of the De Pere dam. In conjunction with WDNR, the FRG selected SMUs 56 and 57 (SMU 56/57) as the project site. The specific goal of this project was to remove 80,000 cy of PCB-contaminated sediment from the site. In late 1999, contractors and consultants under the direction to the FRG designed and implemented the project. Dewatered sediment was moved by truck to a landfill owned and operated by Fort James Corporation (now Georgia Pacific) for disposal. Due cold weather, ice, and other factors, the FRG stopped dredging operations after approximately 31,350 cy of sediments were removed from the River. Following the end of FRG efforts, Fort James Corporation agreed to complete the SMU 56/57 project in Spring 2000 and entered into an Administrative Order By Consent

(AOC) with EPA and the State of Wisconsin (Docket No. V-W-00-C-596). Under the terms of the AOC, Fort James funded and managed the project in 2000 with oversight from WDNR and EPA. Overall, the 1999 and 2000 efforts at SMU 56/57 resulted in the removal of approximately 2,070 pounds of PCBs from the River. In particular, the 2000 project efforts met all goals set forth in the AOC, and also met or exceeded project goals for sediment removal rates, dredge slurry solids, filter cake solids, and production rates that were set forth for the original effort managed by the FRG in 1999.

Like the Deposit N effort, monitoring data from SMU 56/57 project showed that the River was protected during the dredging and that wastewater discharged back to the River complied with all permit conditions. In addition, the project data showed that air releases of PCBs during dredging and handling are so small (essentially zero) such that there is no real risk associated with possible air releases of PCBs. The SMU 56/57 project also demonstrated the ability to use a local landfill for sediment disposal.

2.7 PUBLIC INPUT INTO THE SELECTION PROCESS

Comments from the general public and all stakeholders such as municipalities and the FRG have been received throughout the development process for the RI/FS and Proposed Plan. At each stage of development, the RI/FS and Proposed Plan have been shaped by comments provided to EPA and WDNR. For example, WDNR and EPA received numerous comments regarding the draft RI/FS that was released in April 1999. In response to those comments, the scope of the RI/FS was expanded to include all of Green Bay and numerous supporting studies were completed to more fully consider remediation options for the Site. Following the release of the RI/FS in October 2001, WDNR and EPA again received numerous comments. It should be noted that a formal period for submission of comments was provided and that the time period for comments far exceeded the 30-day minimum time required by the NCP under CERCLA. For example, the comment period following the October 2001 release of the RI/FS and the Proposed Plan lasted more than 3 months. To finalize the RI/FS, WDNR and EPA have prepared a Responsiveness Summary to document responses to comments regarding the RI/FS that were received during the January 2002 formal comment period.

In addition to formal comment periods, WDNR and EPA have participated in an ongoing process for community involvement that has included numerous public meetings since the summer of 1997. These meetings have focused on a variety of topics, including cleanup and restoration activities, the status of pilot projects, fish consumption advisories, and the draft RI/FS. Over this period, WDNR and EPA staff members have made presentations for various community groups. WDNR and EPA also publish a bimonthly newsletter, the *Fox River Current*, which is mailed to over 10,000 addresses. These communication efforts are consistent with National Academy of Science (NAS) recommendations that risk management of PCB-contaminated sediment sites include early, continuous, and frequent involvement of affected parties.

Beyond comment periods and communication efforts, it should be noted that long before formal RI/FS efforts were initiated, the public and the regulated community have been involved and contributed to the remedy selection process for the Lower Fox River. In 1993, a group of paper mills and municipalities approached WDNR to establish a cooperative process for resolving PCB-contaminated sediment issues. The outcome was the formation of the Fox River Coalition, a private-public partnership of businesses, state, and local officials, environmentalists, and others groups committed to improving the quality of the Lower Fox River. The Coalition focused on the technical, financial, and administrative issues that would need to be resolved to achieve a whole river cleanup. The Coalition helped conduct several projects including an RI/FS for several sediment deposits upstream of the De Pere dam, mapping of sediment contamination downstream of the De Pere dam, collection of sediment cores from 113 locations between De Pere and Green Bay, and funding for a portion of the Deposit N pilot project. The results of these Coalition efforts are fully integrated into the present RI/FS.

3 SELECTION OF THE PROPOSED REMEDY

The process used by WDNR and EPA to select the proposed remedy was well-defined and consistent with EPA guidelines for projects conducted under CERCLA. The FS describes a series of alternatives to manage risks attributable to PCBs and other contaminants of concern for each management area of the Site. The Lower Fox River and Green Bay Site is divided into five OUs. These alternatives examined include an array of action levels that range from natural recovery (no action) to successively greater levels of management (lower target residual levels of PCBs) for each OU. A list of the OUs for the Site was presented in Table 1. Each remedial action level (RAL) was evaluated by well-established criteria within the context of a risk management goal. For the Lower Fox River and Green Bay Site, WDNR and EPA established the risk management goal as the elimination of fish consumption advisories for high-intake fish consumers within 10 years and recreational anglers within 30 years.

Consistent with CERCLA guidelines, nine criteria were used to evaluate alternatives. These nine criteria are summarized in Table 4. As part of this evaluation process, the tradeoffs between the degree to which a remedy could reach the risk management goal (Threshold Criteria), the scope and nature of the remedy (Balancing Criteria), and its acceptability (Regulatory Agency and Community Criteria) were considered. The proposed remedy selected by this process represents an optimized combination of the nine criteria in consideration of the overall management goal.

TABLE 4 CERCLA CRITERIA USED TO EVALUATE REMEDIATION ALTERNATIVES

Category	Criteria
Threshold Criteria	1. Overall protection of human health and the environment 2. Compliance with applicable or relevant and appropriate requirements (ARARs)
Balancing Criteria	3. Long-term effectiveness and permanence 4. Reduction of toxicity, mobility, and volume through treatment 5. Short-term effectiveness 6. Implementability 7. Cost
Regulatory Agency and Community Criteria	8. Agency acceptance 9. Community acceptance

A key feature of the remedy selection process for the Lower Fox River and Green Bay was the use of multiple lines of information to determine whether an alternative would comply with the criteria. Each of the supporting studies developed for the RI/FS contributed to remedy selection process. Supporting studies were developed using different assumptions in order to provide the widest possible perspective to inform the remedy selection process. The diversity of perspective that each study provides makes the RI/FS more complete and the Proposed Plan more sound because analyses were not restricted to approaches that favored any individual outcome (i.e., no action vs. action).

In contrast, approaches advocated by others appear to presuppose no action is the only viable alternative.

Under CERCLA, the ROD is the document where a remedy for a site is selected. At this time, WDNR and EPA have issued an ROD for OU 1 (Little Lake Butte des Morts) and OU 2 (Appleton to Little Rapids). The discussion that follows focuses on how the selected remedy satisfies the nine criteria for OUs 1 and 2. While specific to OUs 1 and 2, it is important to note that the remedy selection process described is applicable to the remaining three OUs for the Site.

3.1 Threshold Criteria

As part of remedy evaluation, the ability of each alternative to meet Threshold Criteria was considered. Protection of human health and the environment was evaluated by considering the risk associated with PCBs remaining in surface sediment for each alternative. For this evaluation, the following five conditions were examined:

1. Surface-weighted average residual PCB concentrations in surface sediments;
2. Average PCB concentrations in surface water;
3. The estimated number of years needed to eliminate fish consumption advisories for PCBs;
4. The estimated number of years required to reach surface sediment PCB concentration protective of fish and other biota; and
5. PCB loadings to downstream areas and total mass remediated.

Compliance with applicable or relevant and appropriate requirements (ARARs) was evaluated by considering whether an alternative can meet appropriate federal and state requirements, standards, criteria, and limitations as required by Section 121(d) of CERCLA and NCP § 300.430(f)(1)(ii)(B). Compliance with ARARs is required, unless waived under CERCLA Section 121(d)(4). ARARs are discussed in detail in Section 4 and Section 9 of the FS (RETEC, 2002b) and are also presented in the ROD.

The primary risk to human health is through consumption of fish. The primary risk to the environment is the bioaccumulation of PCBs from the consumption of fish or, for invertebrates, the direct ingestion/consumption of sediment. The sediments of the River and Bay are PCB-contaminated and are the predominant source of PCBs in the system. On a Site-wide basis, human cancer risks were found to be 1,000 times greater than the 10^{-6} (one in one million) cancer risk management level and noncancer hazards were found to be 20 times greater than background risks. Wildlife such as fish-eating birds and mammals were also found to have unacceptably high risk levels. The conclusion that PCBs are unacceptably high is also confirmed by the fact that fish consumption advisories have been in place for this region continuously since the risks were first evaluated in 1976. For both OUs 1 and 2, risks associated with existing conditions in the

Lower Fox River exceed acceptable limits described in risk assessment studies (RETEC, 2002c).

Protection of human health and the environment was evaluated by residual risk in surface sediment using five lines of evidence that include: residual PCB concentrations in surficial sediment using surface-weighted averaging after completion of a remedy; average PCB concentrations in surface water; the projected number of years required to reach safe consumption of fish; the projected number of years required to reach a surface sediment concentration protective of fish or other biota; and PCB loadings to downstream areas and total mass contained or removed.

As described in the FS, increasing levels of sediment management are expected to reduce residual surface sediment PCB concentrations, decrease average PCB concentrations in surface water, reduce the estimated number of years needed to eliminate fish consumption advisories, reduce the estimated number of achieve sediment conditions protective of fish and wildlife; and reduce PCB loadings to downstream areas.

The threshold criteria evaluation concludes that compliance with all ARARs can be achieved and that no waivers are necessary.

3.1.1 Operable Unit 1

Based on consideration listed in Section 3.1, as well as further OU specific information presented in the RI/FS and the BLRA, a level of remediation beyond no action or monitored natural recovery (MNR) is needed to meet threshold criteria for OU 1.

Active remediation in OU 1 is necessary to reduce PCB concentrations in surficial sediment and surface water, reduces the time needed to reach acceptable fish tissue concentrations for humans as well as fish and other wildlife, and will reduce downstream PCB loading into Green Bay to such an extent that active remediation will aid in the recovery of in this OU in an acceptable time. This is further discussed in Section 11 of the ROD for OUs 1 and 2 as well as Sections 5 and 8 of the FS.

3.1.2 Operable Unit 2

Based on considerations listed in Section 3.1, above, as well as OU-specific information presented in the RI/FS and the BLRA, MNR is adequate to meet threshold criteria for OU 2.

Concerning OU 2, MNR may take 40 to 70 years to reach safe fish consumption levels for recreational anglers and may take more than 80 years to reach safe ecological levels for carp. However, the recovery times may be overestimated, as these estimates do not consider the removal of Deposit N, which occurred during 1998–1999. Finally, although active remediation may provide a more protective remedy than MNR, risks would only be moderately reduced.

3.2 BALANCING CRITERIA

As part of remedy evaluation, the ability of each alternative to meet Balancing Criteria was considered. Balancing Criteria are important components that can define major trade-offs between alternatives and serve as important elements in of project goals that require consideration for successful implementation and long term success of a remediation project. These are discussed in Section 11 of the ROD and Section 9 of the FS.

3.2.1 Operable Unit 1

Based on the reduction in residual risk and the adequacy and reliability of controls for the selected remedy, active remediation by dredging with off-site disposal of dewatered sediment is superior to a no action or MNR alternative due to the greater risk reduction and PCB mass removal from OU 1. This remedy also reduces toxicity and mobility of PCB contaminated sediments by eliminating the contaminants from the river thereby reducing the PCB's ability to move in the environment and the amount of contamination present.

Dredging reduces concentrations of PCBs in the sediments' biologically active zone by permanently removing significant contaminated sediment volume and PCB mass from the food web. Furthermore, removal of PCBs will reduce the exposure pathway thus permanently reducing the toxicity associated with the sediments. Disposal of the dewatered sediment into a secure engineered landfill licensed eliminates PCB mobility.

The implementation time for the selected remedy is 6 years at a remedial action level of 1 ppm. This represents the estimated time required for mobilization, operation and demobilization of the remedial work. While the construction of the remedy is underway, access to sediment processing facilities and areas would be restricted to authorized personnel. Work in the river will also be designed with provisions for control of air emissions, noise and light. In summary, the active remediation would not pose significant risk to the nearby communities.

As successfully shown during the Lower Fox River demonstration dredging projects, environmental releases will be minimized during remediation by (1) treating water prior to discharge; (2) controlling storm water run-on and runoff from staging and work areas; and (3) utilizing removal techniques that minimize losses; as well as through (4) the possible use of silt curtains where necessary to reduce the potential downstream transport of PCBs. The active remediation remedy is implementable as well as technically and administratively feasibility. OU 1 costs are estimated to be \$ 66.2 million at an action level of 1 ppm.

Based on these considerations, which are in large part from the RI/FS, active remediation is necessary to address balancing criteria for OU 2.

3.2.2 Operable Unit 2

The MNR alternative does result in continued degradation of sediments and surface water quality of OU 2, which may last for several decades. Nevertheless, OU 2 will eventually recover as a result of slow natural decreases in concentrations. For MNR, fish consumption advisories and fishing restrictions can provide protection to humans until PCB concentrations in fish are reduced to the point where the fish consumption advisories and fishing restrictions can be relaxed or discontinued. Based on the above analysis of reduction in residual risk and adequacy and reliability of controls, active remediation is only marginally better than MNR and there it would be difficult to consistently achieving any remedial action level.

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered. The MNR alternative is implementable as well as technically and administratively feasible as no active measures would be taken for the PCB-contaminated sediments. Certain institutional controls such as fish consumption advisories will be necessary.

For the majority of OU 2, bedrock underlying contaminated sediments could make complete removal of contaminated sediment and achievement of any RAL impracticable. Active remediation could be more difficult due the large number of locks (many of which are in a state of disrepair) and dams, which limit River access and navigation. The MNR remedy is implementable as well as technically and administratively feasible. Costs for OU 2 are estimated to be $ 9.9 million.

In addition to the above practical considerations, achieving of contaminant concentration (i.e., risk) reductions would be more difficult for dredging areas where bedrock immediately underlies contaminated sediment. Results on projects such as Deposit N or projects with similar conditions (e.g., Manistique River/Harbor) support the idea that achieving reductions in contaminant concentrations would be difficult. Thus, a dredging remedy for this portion of the River would be expected to be less effective and could be more costly for likely only modest risk reduction.

Based on these considerations, which are in large part from the RI/FS, MNR will be adequate to address balancing criteria for OU 2.

3.3 REGULATORY AGENCY AND COMMUNITY CRITERIA

State and community acceptance are modifying considerations that are usually taken into formal consideration once public comments have been received. These issues are the same for both OUs 1 and 2. However, at the Lower Fox River and Green Bay Site, the State of Wisconsin has been actively involved in managing the resources of the Lower Fox River since before there was a federal Superfund law. These efforts have led to significant state knowledge and understanding of the River and Bay and of the contamination problems within those areas. As a result of this expertise, WDNR has served as the lead agency responsible for assessing risks and conducting the RI/FS, which forms the basis for the Proposed Plan and ROD. As the lead agency, WDNR has worked closely with EPA to cooperatively develop the ROD. Both WDNR and EPA support the selected remedy identified in the ROD.

Community Acceptance considers whether the local community agrees with EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance. Community acceptance of the Proposed Plan was evaluated based on comments received at the public meetings and during the public comment period. There were more than 4,800 comments concerning the Proposed Plan. The ROD includes a Responsiveness Summary, Appendix B, that addresses public comments.

Based on the information listed in Sections 3.1 to 3.3, as well as further OU-specific information presented in the RI/FS and the BLRA, a level of remediation beyond no action or MNR is needed to meet CERCLA threshold, balancing, and acceptance criteria for OU 1. However, based on the information in Sections 3.1 to 3.3, as well as OU-specific information presented in the RI/FS and the BLRA, MNR is adequate to meet CERCLA threshold, balancing, and acceptance criteria for OU 2.

3.4 Other Factors

In addition to consideration of the nine CERCLA criteria, discussion of two additional factors in the evaluation of alternatives is worthwhile. This first factor is the potential for the direct release of PCB during active dredging. The second factor is the potential of thin patinas (residual layers) following dredging. In particular, long-term simulations completed using the site-specific chemical transport and bioaccumulation models developed for the RI/FS do not include explicit representations of the potential for direct PCB releases during dredging operations and potential for thin patinas or residual layers to occur immediately following the end of dredging operations. These factors are believed to be of secondary importance. Including or neglecting these factors is not believed to affect the selection of the remedy. Discussion of these two factors follows.

3.4.1 Direct Releases PCBs During Active Dredging Operations

Direct releases of PCBs can occur during dredging active operations. Such direct releases of PCBs were not explicitly included in the site-specific chemical transport and bioaccumulation models developed for the RI/FS. This model design factor was based on consideration of the scale of annual PCB mass transport through the River and the ability to control potential releases during dredging. As monitored during the Deposit N and SMU 56/57 demonstration projects, the mass of PCBs released by dredging was roughly two orders of magnitude smaller (less than 1 percent) than the present level of ongoing PCB transport through the Lower Fox River. Assuming full-scale dredging operations were initiated, direct releases of PCBs during dredging (a few kilograms per year) would always be far smaller than natural transport rates (several hundred kilograms per year). Further, as documented by the Sediment Technologies Memorandum (Appendix B of RETEC, 2002b) direct PCB releases during dredging can be minimized by the use of careful controls for during dredging. Note that direct releases of PCBs as a result of propeller wash and bow thrusters by ships traversing the River may be a more significant loss (and uncontrollable) release mechanism. Based on these considerations, direct losses of PCBs during dredging were considered negligible.

3.4.2 Post-Dredge Patinas/Residual Layers

Immediately following dredging the end of dredging operations, it is possible that patinas (thin residual layers) of more highly PCB-contaminated sediments may exist at the sediment-water interface. Such patinas were not explicitly included in the site-specific chemical transport and bioaccumulation models developed for the RI/FS. This model design factor was based on consideration of the ability of dredging technologies to achieve low residual PCB concentrations and the rapid rate at which conditions at the sediment-water interface are expected to change following dredging. As monitored following first phase of the SMU 56/57 demonstration project in 1999, PCB concentrations in portions of the dredged area where post-dredging bed elevation meet the target elevation were approximately equal to PCB concentrations initially present at that sediment depth (WDNR, 2000d). This indicates that low residual PCB levels can be achieved by careful control of dredging to ensure sediments are removed with minimum disturbance to a depth required to achieve a desired residual. In addition, dredging alters the sediment transport regime of the dredged area. As a result, conditions near the sediment-water interface can change rapidly following dredging. Post-dredging monitoring of the SMU 56/57 site showed that rapid changes in the sediment-water interface occurred and that conditions a few months following dredging did not resemble conditions immediately following dredging (WDNR, 2002). Based on these considerations, the effect of PCBs potentially present in post-dredge patina layers was considered negligible.

4 SUMMARY OF THE SELECTED REMEDY

Taking into account the factors examined as part of the supporting studies, other information in the RI/FS, and public comments, WDNR and EPA recommend the cleanup actions listed in the Proposed Plan (see Table 5 in WDNR and EPA, 2001) for the Lower Fox River and Green Bay. At this time, the Agencies are issuing an ROD for OUs 1 and 2. The selected remedy is consistent with the Proposed Plan for these two OUs.

The are several strong reasons for issuing an ROD for OUs 1 and 2 at this time. These reasons include:

- OUs 1 and 2 represent a smaller portion of the area within the Lower Fox River where remediation is necessary. These two OUs represent approximately 6.5 percent of the PCB mass and 18 percent of the sediment volume in the lower Fox River. Consequently, these two OUs represent a more manageable project than conducting all of the remediation at one time.

- This approach provides for a phased approach to remedial work. Work on upstream areas can start before the downstream areas, which is consistent with EPA policy.

- Planning for OUs 3, 4, and 5 may benefit from knowledge gained on the OUs 1 and 2 project.

- Removal of the PCB-contaminated sediments from OU 1 will result in reduced PCB concentrations in fish tissue, thereby accelerating the reduction in potential future human health and ecological risks in that OU.

- In addition, by addressing the sediments, the remediation will address sources of PCBs upstream of OUs 3 through 5. WDNR and EPA expect to issue a remedy for OUs 3 through 5 in the future.

WDNR and EPA carefully considered more and less stringent cleanup levels (RALs) before selecting the 1 ppm level and believe the 1 ppm RAL is important to achieve the timely reduction of risks to an acceptable level. The selection of the cleanup level is the outcome of a complete and scientifically based risk evaluation. In selection of the 1 ppm RAL, WDNR and EPA considered Remedial Action Objectives (RAOs), model forecasts of the time necessary to achieve risk reduction, risk reduction, the post-remediation Surface-Weighted Average Concentration (SWAC), comparison of the residual SWAC concentration to SQTs for human and ecological receptors, sediment volume and PCB mass to be managed, and cost. The 1 ppm RAL achieves the Agencies' remedial action goals. WDNR and EPA believe this RAL selection is consistent with the 1999 Draft RI/FS. The 1999 Draft RI/FS called for an action level of 0.250 ppm or 0.250 ppm SWAC. The SWAC value resulting from the 1 ppm action level is 0.19 ppm in OU 1.

TABLE 5 RECOMMENDED REMEDIATION PLAN FROM THE LOWER FOX RIVER AND GREEN BAY PROPOSED PLAN

Operable Unit	Selected Remedy	PCB Mass Removed (kg)	Contaminated Sediment Volume to Manage (cy)	Estimated Cost (Million $)	Residual SWAC (ppm)
1	Dredge with off-site disposal to 1 ppm PCBs	1,715	784,200	66.2	0.19
2	Monitored natural recovery	0	0	9.9	0.61
3	Dredge with off-site disposal to 1 ppm PCBs	1,111	586,800	43.9	0.26
4	Dredge with off-site disposal to 1 ppm PCBs	26,433	5,879,500	173.5	0.16
5	Monitored natural recovery	0	0	39.6	Not Applicable

5 CONCLUSIONS

Information from many different sources and supporting studies identified the need to implement an active remediation strategy for the Lower Fox River and Green Bay. While no single source of information or study findings in and of itself leads to selection of a remedy, the combination of these findings provides a clear weight of evidence supporting the selection of the remedy described in Sections 3 and 4 for OUs 1 and 2. An approach consistent with this will be followed for OUs 3 through 5. These findings can be categorized in a fashion consistent with the three groupings of the EPA NCP nine CERCLA criteria. The specific findings include:

- **Threshold Criteria**
  - Risks to human health and the ecosystem are unacceptable. Natural recovery has not effectively reduced risks in the 30-plus years timeframe since the manufacturing and recycling of PCB-contaminated carbonless copy paper has ceased. Furthermore, dechlorination in the Lower Fox River appears limited to concentrations that are greater than 30 mg/kg (ppm). This is far above the 1 ppm RAL.
  - WDNR and EPA objectives are to eliminate consumption advisories for recreational anglers within 10 years of completion of remediation and within 30 years for high-intake fish consumers.
  - Comparative modeling shows that active remediation will result in risk reduction more quickly than either the MNR or no action alternatives and will achieve WDNR and EPA risk reduction objectives for certain fish species.
  - Managing to a specific RAL will result in a specific risk-based, surface-weighted action level in any given OU.
  - This work can be completed while complying with ARARs of state and federal rules.

- **Balancing Criteria**
  - There is a large amount of PCBs and contaminated sediment in the Lower Fox River and Green Bay. Much of this sediment is found in the top 100 cm of the sediment bed that can be managed by dredging.
  - The sediment bed in the River is dynamic resulting in resuspension and downstream transport of PCBs in the water column.
  - Dredging technologies can achieve both short-term (e.g., remove to specific elevation or concentration, minimal resuspension of contaminated sediment) as well as long-term goals (e.g., removal of fish consumption advisories) for OU 1.

- ► An effective post-remediation monitoring program is needed to ensure and measure the effectiveness of any remedial action

- **Regulatory Agency/Community Criteria**

  - ► WDNR and EPA have worked together on the selection of this remedy and both are in agreement with the selection for OUs 1 and 2.
  - ► WDNR and EPA have taken many steps to inform the public of the work being conducted on the Lower Fox River and Green Bay and have used that input to in preparing documents.
  - ► Comments submitted by the public have been considered in the selection of this remedy for OUs 1 and 2. The responses to comments received during the public comment period are included in the Responsiveness Summary that accompanies the ROD for OUs 1 and 2.

6 REFERENCES

AGI, 2000. *Peer Review of Models Predicting the Fate and Export of PCBs in the Lower Fox River below the De Pere Dam: A Report of the Lower Fox River Fate and Transport Peer Review Panel*. J. C. Tracy and C. M. Keane (eds). American Geological Institute, Alexandria, Virginia. 88 p.

Bierman, V. J., J. V. DePinto, T. C. Young, P. W. Rodgers, S. C. Martin, R. Raghunathan, and S. C. Hintz, 1992. *Development and Validation of an Integrated Exposure Model for Toxic Chemicals in Green Bay, Lake Michigan*. Prepared for United States Environmental Protection Agency, Large Lakes and Rivers Research Branch, Environmental Research Laboratory, Duluth, Michigan. September 1.

Connolly, J. P., 1991. Application of a food chain model to polychlorinated biphenyl contamination of the lobster and winter flounder food chains in New Bedford Harbor. *Environ. Sci. Technol*. 25:760–770.

Connolly, J. P., T. F. Parkerton, J. D. Quadrini, S. T. Taylor and A. J. Thuman, 1992. *Development and Application of a Model of PCBs in the Green Bay, Lake Michigan Walleye and Brown Trout and Their Food Webs*. Report to the United States Environmental Protection Agency, Grosse Ile, Michigan. Cooperative Agreement CR-815396.

Connolly, J. P. and R. V. Thomann, 1992. Modeling the Accumulation of Organic Chemicals in Aquatic Food Chains. In: *Fate of Pesticides and Chemicals in the Environment*. J. L. Schnoor (ed). John Wiley & Sons, Inc. p. 385–406.

Connolly, J. P. and R. Tonelli, 1985. A model of kepone in the striped bass food chain of the James River Estuary. *Est. Coastal Shelf Sci*. 20:349–366.

DePinto, J. V, V. J. Bierman, and T. C. Young, 1993. *Recalibration of GBTOX: An Integrated Exposure Model For Toxic Chemicals in Green Bay, Lake Michigan*. Prepared for United States Environmental Protection Agency, Large Lakes and Rivers Research Branch, Environmental Research Laboratory, Grosse Ile, Michigan. December 31.

Dinehart, R. L., 2002. Bedform movement recorded by sequential single-beam surveys in tidal rivers. *Journal of Hydrology*. 258(1–4):25–39.

EPA, 2002. *White Paper No. 3 – Fox River Bathymetric Survey Analysis*. United States Environmental Protection Agency, Region 5, Superfund Division, FIELDS Team. December.

Gobas, F. A. P. C., 1993. A model for predicting the bioaccumulation of hydrophobic organic chemicals in aquatic food-webs: Application to Lake Ontario. *Ecological Modeling*. 69:1–17. December 8.

Gobas, F. A. P. C., M. N. Z'Graggen and X. Zhang, 1995. Time response of the Lake Ontario ecosystem to virtual elimination of PCBs. *Environmental Science & Technology*. 29(8):2038–2046.

HydroQual, Inc., 1995. *Addendum to Green Bay Final Report: Food Chain Model Projections*. Prepared for United States Environmental Protection Agency, Grosse Ile, Michigan.

HydroQual, Inc., 1996. *Green Bay Food Chain Model Documentation*. Prepared for United States Environmental Protection Agency, Grosse Ile, Michigan.

HydroQual, 2001. *Enhancement and Application of a PCB Fate and Transport Model for Green Bay – Lower Fox River/Green Bay Remedial Investigation and Feasibility Study*. Prepared for Wisconsin Department of Natural Resources by HydroQual, Inc. June.

LTI, 2002. *Measurement of Burial Rates and Mixing Depths Using High Resolution Radioisotope Cores in the Lower Fox River*. Limno-Tech, Inc., Ann Arbor, Michigan. 95 p.

QEA. 2001. *A Model of PCB Bioaccumulation in the Lower Fox River and Green Bay: GBFood*. Prepared for ThermoRetec Consulting Corporation by QEA, LLC, Montvale, New Jersey. June.

RETEC. 2002a. *Final Remedial Investigation for the Lower Fox River and Green Bay, Wisconsin, Remedial Investigation and Feasibility Study*. Prepared for Wisconsin Department of Natural Resources by The RETEC Group, Inc., St. Paul, Minnesota. December.

RETEC. 2002b. *Final Feasibility Study for the Lower Fox River and Green Bay, Wisconsin, Remedial Investigation and Feasibility Study*. Prepared for Wisconsin Department of Natural Resources by The RETEC Group, Inc., Seattle, Washington. December.

RETEC. 2002c. *Final Baseline Human Health and Ecological Risk Assessment for the Lower Fox River and Green Bay, Wisconsin, Remedial Investigation and Feasibility Study*. Prepared for Wisconsin Department of Natural Resources by The RETEC Group, Inc., Seattle, Washington and Pittsburgh, Pennsylvania. December.

Steuer, J., S. Jaeger, and D. Patterson, 1995. *A Deterministic PCB Transport Model for the Lower Fox River Between Lake Winnebago and De Pere, Wisconsin*. PUBL WR 389-95. Wisconsin Department of Natural Resources. May. 283 p.

Tetra Tech, Inc., 2000. *Overview of Sediment-Contaminant Transport and Fate Models for Use in Making Site-Specific Contaminated Sediment Remedial Action Decisions*. Prepared for United States Environmental Protection Agency OERR (5204G) by Tetra Tech, Inc., Fairfax, Virginia.

ThermoRetec, 2001. *Lower Fox River/Green Bay Remedial Investigation and Feasibility Study: Fox River Food (FRFood) Model Documentation Memorandum*. Prepared for Wisconsin Department of Natural Resources by ThermoRetec Consulting Corporation. June.

TMWL, 2002. *Time Trends in PCB Concentrations in Sediment and Fish: Lower Fox River and Green Bay, Wisconsin*. Prepared for Wisconsin Department of Natural Resources by The Mountain-Whisper-Light Statistical Consulting, Seattle, Washington and The RETEC Group, Inc., Seattle, Washington. December.

Velleux, M. and D. Endicott, 1994. Development of a mass balance model for estimating PCB export from the Lower Fox River to Green Bay. *Journal of Great Lakes Research*. 20(2):416–434.

Velleux, M., D. Endicott, J. Steuer, S. Jaeger, and D. Patterson, 1995. Long-term simulation of PCB export from the Fox River to Green Bay. *Journal of Great Lakes Research*. 21(3):359–372.

Velleux, M., J. Gailani, and D. Endicott, 1996. Screening-level approach for estimating contaminant export from tributaries. *ASCE Journal of Environmental Engineering*. 122(6):503–514.

Velleux, M., J. Killian, G. Statz, S. Jaeger, D. Damiani, and E. Garland, 2001. *Development and Application of a PCB Transport Model for the Lower Fox River – Lower Fox River/Green Bay Remedial Investigation and Feasibility Study*. Prepared by Wisconsin Department of Natural Resources. June 15.

WDNR, 1997. *Polychlorinated Biphenyl (PCB) Contaminated Sediment in the Lower Fox River: Modeling Analysis of Selective Sediment Remediation*. PUBL-WT-482-97. Wisconsin Department of Natural Resources, Bureau of Watershed Management, Madison, Wisconsin. February.

WDNR, 1999a. *Technical Memorandum 2d: Compilation and Estimation of Historical Discharges of Total Suspended Solids and PCB from Lower Fox River Point Sources*. Wisconsin Department of Natural Resources, Madison, Wisconsin. February 23.

WDNR, 1999b. *Technical Memorandum 2g: Quantification of Lower Fox River Sediment Bed Elevation Dynamics through Direct Observations*. Wisconsin Department of Natural Resources, Madison, Wisconsin. July 23.

WDNR, 1999c. *Technical Memorandum 2e: Estimation of Lower Fox River Sediment Bed Properties*. Wisconsin Department of Natural Resources, Madison, Wisconsin. March 31.

WDNR, 1999d. *Analysis of COE Sounding Data at 56/57*. Memorandum prepared by Jim Killian. Wisconsin Department of Natural Resources, Madison, Wisconsin. September 27.

WDNR, 2000a. *Addendum to Technical Memorandum 2e: Estimation of Sediment Bed Properties for the Lower Fox River (4 reach effort)*. Memorandum prepared by G. Fritz Statz. Wisconsin Department of Natural Resources, Madison, Wisconsin. October 26.

WDNR, 2000b. *Technical Memorandum 2f: Estimation of Sediment Bed Properties for Green Bay*. Wisconsin Department of Natural Resources, Madison, Wisconsin. December 15.

WDNR, 2000c. *Screening-Level Model of PCB Transport in the Sheboygan River*. Wisconsin Department of Natural Resources, Madison, Wisconsin. December 31.

WDNR, 2000d. *Post-Dredging Results for SMU 56/57*. Memorandum prepared by Bob Paulson. Wisconsin Department of Natural Resources, Madison, Wisconsin. February 21.

WDNR, 2001a. *Development and Application of a PCB Transport Model for the Lower Fox River*. Wisconsin Department of Natural Resources, Madison, Wisconsin. June 15.

WDNR, 2001b. *Estimation of Contemporary Net Burial Rates from the Depth of PCB Occurrence in the Lower Fox River Sediments*. Memorandum prepared by Mark Velleux. Wisconsin Department of Natural Resources, Madison, Wisconsin. March 23.

WDNR, 2002. *2002 Benthic and Sediment Sampling at Fox River Remediation Site Hotspot 56/57*. Memorandum prepared by Jim Killian. Wisconsin Department of Natural Resources, Madison, Wisconsin. November 26.

WDNR and EPA, 2001. *Proposed Remedial Action Plan, Lower Fox River and Green Bay*. Wisconsin Department of Natural Resources, Madison and Green Bay, Wisconsin and United States Environmental Protection Agency, Region 5, Chicago, Illinois. October.

WNDR and RETEC, 2002. *Final Model Documentation Report for the Lower Fox River and Green Bay, Wisconsin, Remedial Investigation and Feasibility Study*. Wisconsin Department of Natural Resources, Madison, Wisconsin and The RETEC Group, Inc., Seattle, Washington. December.